REMARKS

A petition for a one month extension of time has today been filed as a separate paper and a copy is attached hereto.

As the examiner has correctly noted in the comments of paragraph 2, the wording of claim 29 was inconsistent with the teaching at page 12, lines 2-6 of the original specification describing the embodiment employing hydrocarbon, i.e., as defined by claim 29. Accordingly, responsive to the examiner's rejection for indefiniteness, claim 29 has been amended to delete "nitriding", i.e., language used to describe a different embodiment.

Responsive to paragraph 3 of the office action, claim 32 has been amended to correctly recite the fact that the silicon-containing insulating layer is formed on the "diffusion preventing layer" rather than on the "copper wiring layer."

The rejection of claims 29, 30, 32 and 36 for obviousness over Yang et al in view of Ngo et al is respectfully traversed. In explaining the rejection as applied to claim 29 the examiner writes:

> Yang et al teaches converting into a plasma a process gas containing N_2O and a hydrocarbon C_XH_Y; and converting a surface portion into a copper diffusion preventing layer by exposing a surface of the copper wiring layer to the process gas plasma. See columns 3-7, lines 45-50 and Fig. 1. [Emphasis added.]

The examiner's characterization notwithstanding, Yang et al does not teach formation of any "copper diffusion preventing layer." The objective of Yang et al is to produce a lower dielectric constant material which, according to their specification, is a

"carbonaceous silicon oxide." See, for example, column 1, lines 40-43 and 53-57, column 2, lines 29-31 and column 2, line 36. The problem with lowering the dielectric constant of the insulating film, e.g., interconnect dielectric material as in Yang et al, is that the lower dielectric constant translates to a higher degree of copper diffusion. See page 3, lines 22-25 and page 2, lines 13-24 of applicants' original specification. In this sense, the objective of Yang et al in forming a lower K dielectric film is the opposite of that of applicants' process for forming a copper diffusion preventing layer. However, by formation of a copper diffusion preventing layer in accordance with the present invention, low dielectric constant films, as interlayer insulating films separating copper wiring layers is enabled. See page 3, line 12 to page 4, line 7 of applicants' original specification.

Further, even if the teachings of Ngo et al are combined with those of Yang et al, the result would not be anything resembling applicants' process as claimed. Ngo et al teaches treating the surface of the copper interconnects "to effect oxide layer removal." See column 4, lines 35-40 and column 5, lines 57-64. Subsequent to the reduction and removal of copper oxide, a silane is introduced to form "a high density plasma silicon nitride capping layer 40." See column 5, lines 64-66 and column 4, lines 39 and 40. Summarizing, neither Yang et al nor Ngo et al suggest formation of a plasma "consisting essentially of N_2O and a hydrocarbon C_XH_Y" or its use to form a "copper diffusion preventing layer." Accordingly, no combination of features of the two processes would result in applicants' invention as defined by claim 29.

Parenthetically, Ngo et al nowhere describe their treatment with a "plasma containing ammonia and nitrogen" as a nitriding reaction or as "nitridation."

Claim 30

It is acknowledged that Ngo et al teach formation of a plasma from a gaseous mixture of ammonia and nitrogen. However, such a plasma is not suggestive of a plasma formed from a gas "consisting essentially of N_2O and a hydrocarbon." Further, as noted above, Ngo et al nowhere suggest that such a plasma "nitrides" the copper surface.

Claim 31

Claim 31 is rejected over the combination of Yang et al and Ngo et al further in view of Pramanick et al.

Pramanick et al employs pretreatment with an ammonia plasma prior to deposition of a diffusion preventing layer. In this sense, its teaching seems to be redundant with those of Ngo relied upon by the examiner. It is respectfully submitted that it would not have been obvious to add the ammonia pretreatment of Pramanick et al to the hypothetical combination of Yang et al and Ngo et al because the purpose of the Pramanick et al pretreatment is to remove the oxide from the surface of the copper conductor (column 4, lines 25-28 of Pramanick et al), which is the same purpose served by pretreatment with the ammonia and nitrogen plasma in Ngo et al. In other words, based on the teachings of the reference, the two steps would be considered redundant.

Claim 32

Claim 32 stands rejected over the combination of Yang et al and Ngo et al.

This rejection is traversed for the same reason that rejection of claim 29, from which claim 32 depends, was traversed above.

Claim 33

The examiner rejects claim 33 for obviousness over a combination of Yang et al, Ngo et al and Matsuda et al. The latter reference is cited for its alleged disclosure of the additional step recited by claim 33.

The rejection is respectfully traversed for the reason that the rejection of claim 29 was traversed and for the additional reason that the teachings of Matsuda et al would not be applicable to those of Ngo et al and Yang et al. It is respectfully submitted that it would not have been obvious to combine the teachings of Matsuda et al with those of Yang et al and Ngo et al in the manner suggested by the examiner. Matsuda et al teaches forming a barrier layer "selectively and in a self-aligned manner relative to the copper wiring", quoting from column 3, lines 23-29. Referring to Figs. 5A-5C of Matsuda et al, the copper wiring shown as 14 in Fig. 5A is selectively covered with a silicon film 15 as shown in Fig. 5B. That silicon film 15, limited to the area covering the copper conductor, is subsequently converted to a silicon nitride film 16 as shown in Fig. 5C. This process of Matsuda et al in forming a barrier layer, in a limited area covering each of the copper wirings, is said to prevent an increase in the capacitance between copper wiring which inevitably occurs "in the conventional method of forming a silicon nitride film on the entire surface." Again, refer to column 3, lines 23-29 of Matsuda et al.

Accordingly, there would have been no motivation to treat, for example, the silicon dioxide layer 41 of Ngo et al in the manner suggested by Matsuda et al for several reasons. Firstly, that layer 41 covers a barrier layer or capping layer 40 and no useful purpose would be served by converting the entire silicon oxide layer 41 to a barrier layer. Indeed, such a conversion would increase the dielectric constant and be counterproductive. Further, treatment of the silicon oxide layer 41 of Ngo et al would not be accordance with the teachings of Matsuda et al which eschews formation of a silicon nitride film over the entire surface.

Claim 34

The rejection of claim 34 over Yang et al, Ngo and Islam et al is respectfully traversed for the reasons the rejection of claim 29, from which claim 34 depends, is traversed above.

Claim 35

The rejection of claim 35 over the combination of Yang et al and Ngo et al, further in view of Islam et al and Smith is respectfully traversed for the same reason that claim 29, from which it indirectly depends, is traversed above.

Claim 36

The rejection of claim 36 is likewise traversed for the reason that the rejection of claim 29 is traversed above, in view of the fact that claim 36 depends from claim 32 and indirectly from claim 29.

Double Patenting Over Shioya et al in View of Ngo et al

It is respectfully submitted that the present amendments to claim 29 serve to obviate the basis for the double patenting rejection in that the new language of claim 29 would exclude any additional component, such as the HMDSO of Shioya et al, which would serve to alter the nature of a plasma and the basic chemical make-up of the barrier film. It is respectfully that claim 29 as amended should be interpreted as excluding the additional presence of any silicon compound from the process gas from which the plasma is formed.

In conclusion, it is respectfully requested that the examiner reconsider the rejections of record with a view toward allowance of the claims as amended.

Respectfully submitted,

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